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COASTAL LANDFORMS
BETWEEN TILLAMOOK BAY AND THE COLUMBIA RIVER, OREGON

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The 50-mile stretch of the Oregon coast between Tillamook Bay and the Columbia River can be divided into three nearly equal segments according to the kinds of landforms along them. The southern segment extends from Tillamook Bay to Neahkahnie Mountain (map 1), the middle from Neahkahnie Mountain to Tillamook Head inclusive (map 2), and the northern from Tillamook Head to the Columbia River (map 3). The discussion of the landforms is presented in the order of these divisions.

In preparing this article, an attempt was made to use as few technical terms as possible in view of the fact that many of The ORE BIN readers may not have had formal education in the earth sciences. It is not possible, however, to avoid all technical terms in a presentation such as this; therefore, a glossary of words most likely to be troublesome is available at the end of the article.

Tertiary Bedrock and its Role in Landform Development

Bedrock along this part of the Oregon coast consists of marine sedimentary strata of Oligocene to mid-Miocene age and Miocene basalt of intrusive and extrusive varieties. The sedimentary rocks have been subdivided by Schlicker and others (1972) into two parts: unnamed strata of Oligocene to mid-Miocene age and the middle Miocene Astoria Formation as redefined. Miocene sedimentary rocks and basalt are in part contemporaneous, and in places the two are interbedded (Snavely and Wagner, 1963). Their distribution is the main factor in the development of the shore's configuration and of the landforms along it.

Marine sedimentary rocks

Many of the coastal exposures consist of sedimentary strata assigned to the Astoria Formation. The deposits were probably laid down in shallow marine embayments along the western margin of Oregon during middle Miocene time after the Coast Range uplift had begun. Beds vary from place to place in rock type but consist mainly of olive-gray sandstone and dark-gray siltstone and shale. There are also beds of yellowish-gray, water-laid volcanic ash that range from a few inches to 18 feet in thickness, and because the ash is similar in composition to ash of the same age in the western Cascades, it is believed to have come from eruptions in an ancestral Cascade Range (Snavely, Rau, and Wagner, 1964). In comparison to the basalt, the sedimentary rock is weak in its ability to withstand erosion, and it is in this rock that the coves, bays, and other re-entrants along this part of the coast are formed.

Basalt

At the time lava was pouring out of the earth to form the Columbia River Basalt in the Columbia River Gorge and the basalt layers of the Columbia Plateau, basalt lava was erupting from vents near the present shoreline. Some of the basalt erupted under the sea, or poured into it, where it became complexly intermixed with the sediment on the sea floor. The rock of these flows is usually fragmental in contrast to the more homogeneous, dense rock that poured out on land. Associated with the flows are intrusions, mainly dikes and sills, that solidified at shallow depth beneath the earth's surface. The rock of the smaller intrusions is fine grained and dense, but in the larger ones the grain size is coarse enough that individual mineral grains are readily discernable. Some is sufficiently coarse to be classed as gabbro, the coarse-grained equivalent of basalt.

Basalt was once continuous over a large area along the northern part of the Oregon coast and inland from it and probably was continuous with basalt of the Columbia River Gorge and the Columbia Plateau. Only remnants, mainly at or near centers of eruption, are left, and where they are located along the shore, they form the prominent headlands and points and the reefs, stacks, and arches just offshore from them.

Differences in hardness of the basalt from place to place and fractures and shear zones cutting through it have contributed to different rates of erosion, and differential erosion accounts for the variety of forms developed on basalt along the shore and offshore. Masses of hard rock surrounded by less resistant rock get isolated from the mainland by wave erosion to form the stacks and arches. The aligned rock reefs are remnants of what was once mainland. Trenches are cut into the basalt where it has been fractured, and caves penetrate the sea cliff along fractures or where a weak layer is exposed within reach of the waves. The irregularity of a given rock mass is a function of the rate at which its parts get removed by erosion, the attack of the waves being guided by the weak places.

Quaternary Deposits

Terrace deposits

Terraces are not as prevalent along this part of the Oregon coast as they are along the central and southern parts. However, in a number of places terrace sand and gravel are preserved over a wave-cut bench of Pleistocene age. The terrace was eroded into the marine sedimentary rocks at a time when sea level stood higher relative to the land than it does now. In places the terrace deposits are covered by sand dunes, and the bench form of the terrace is obscured.

Dune sand

Dunes are extensive in the southern and northern segments, where they occupy the lowland areas underlain by marine sedimentary bedrock. Sea cliffs along the shore of the middle segment have prevented dune development there, except at the mouth of Elk (Ecola) Creek. The complicated cross bedding seen in some road cuts through dunes is the diagnostic feature that distinguishes dune sand from the horizontally bedded terrace sand.

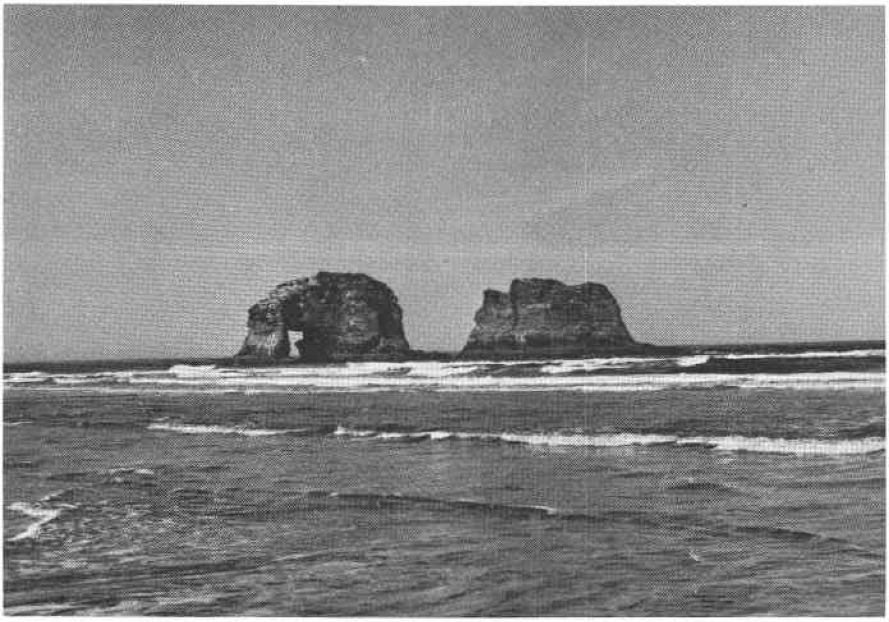


Figure 1. Twin Rocks are offshore remnants of basalt. The one at the left is an arch and the other a stack.

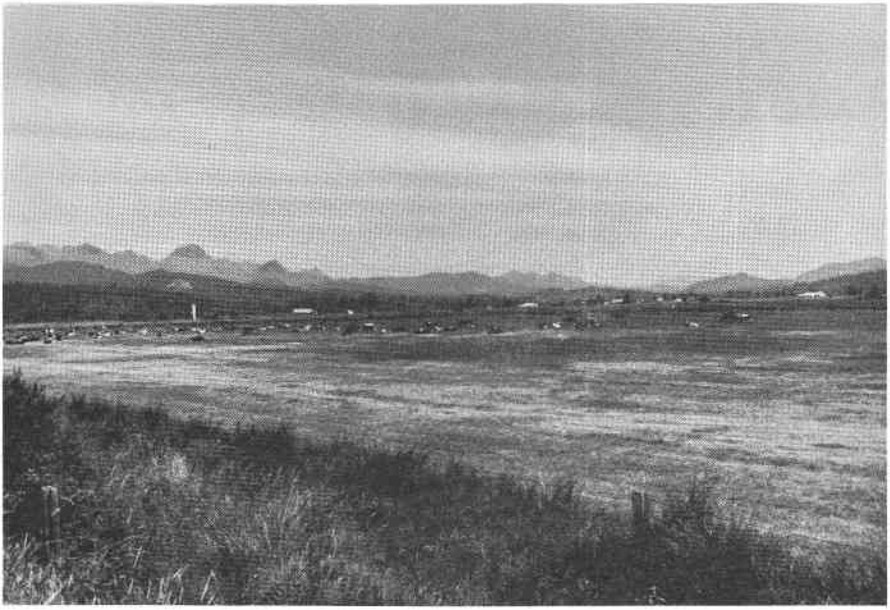


Figure 2. Alluvial plain of Nehalem River formed during the Pleistocene at a time of higher sea level.

Alluvium

Deep alluvial deposits are extensive along the major streams and around the bays. Sand, silt, and mud are presently being deposited by streams, especially at their lower ends where their flow is checked by tidal currents. Much of the sediment, however, was laid down at times during the Quaternary when the condition of flooding was promoted by higher sea levels.

Landforms

Southern segment (map 1)

The shore from Tillamook Bay to the base of Neahkahnie Mountain is bordered by a sand beach that is continuous except where it is interrupted by the Nehalem River. Aside from some very small areas of basalt that lie back from the beach and Twin Rocks that lie just offshore opposite the Twin Rocks community, the area is underlain by marine sedimentary strata.

At the southern end is Tillamook Bay, a large bay lying behind a sand peninsula that projects northward from Cape Meares. The water body is shallow over most of its extent, and it covers only about a fourth of the area once occupied by water in a Pleistocene embayment. The other three-fourths has been filled by bay sediment and river alluvium laid down by the Tillamook, Trask, Wilson, Kilchis, and Miami Rivers and smaller streams that flow into the bay.

Small sea stacks and an arch just inside the bay about three-quarters of a mile east of Barview were formed when waves of the open ocean washed this part of the bay shore. These stacks are unusual in that they are composed of sedimentary rock.

Between Tillamook Bay and the mouth of Nehalem Bay is a narrow strip of coastal plain that is on a low bench cut on marine sedimentary rock. The western edge of the strip is occupied by dunes that begin in a dune complex just north of the outlet of Tillamook Bay and continue in a dune ridge that extends northward just behind the shore. A low, relatively level terrace surface lies between the dune ridge and the upland. Small lakes, the largest of which are Smith Lake, Crescent Lake, and Lake Lytle, are impounded by the dunes.

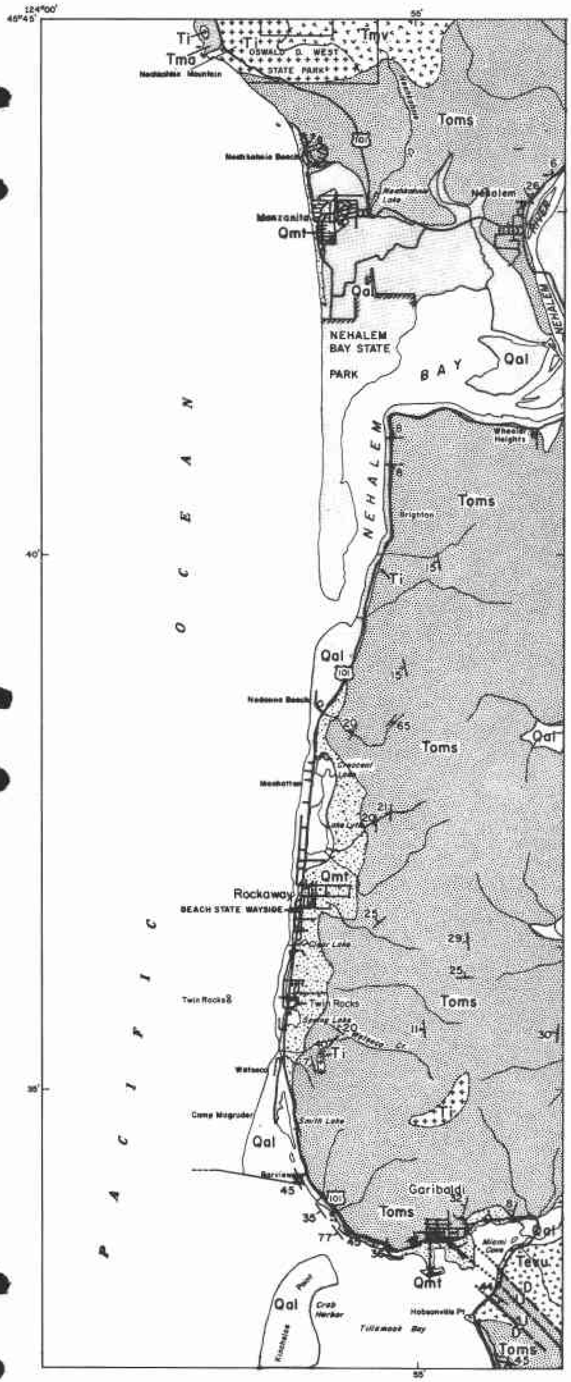
Two basalt remnants, Twin Rocks (Figure 1), lie a few hundred feet off the Beach at the Community of Twin Rocks south of Rockaway. One of them is a sea stack and the other is an arch.

At its north end, the narrow coastal plain strip is terminated by Nehalem Bay, the estuary of Nehalem River. As with Tillamook Bay, Nehalem Bay occupies only a fraction of the area of an earlier Pleistocene embayment. Bay filling and deposition of alluvium by the Nehalem River have formed an alluvial plain that extends inland along the river for nearly 10 miles (Figure 2). The fertile alluvial plains around several bays, including Tillamook and Nehalem, and along the many coastal streams support the Tillamook County dairy industry, which produces world-famous Tillamook cheese.

Projecting southward in front of Nehalem Bay is a long sand peninsula, a sandspit, that deflects the flow of the Nehalem River southward $2\frac{1}{2}$ miles from the main body of the bay (Figure 3). Sandspits such as this have formed at the mouths of bays all along the Oregon coast. Some project northward and others southward, the direction being determined mainly by whether they are influenced more by the northward

MAP 1

Tillamook Bay to Neahkahnie Mountain



EXPLANATION

Qal — Alluvium and dune sand

Qmt — Marine terraces

UNCONFORMITY

Tmv — Miocene volcanic rocks
Localized accumulations of massive basalt breccia, basalt flows, palagonitic breccias and pillow basalts

Ti — Intrusive rocks
Middle to late Miocene basaltic intrusive rocks which include thick sills

UNCONFORMITY

Toms — Oligocene to Miocene sedimentary rocks
Over 5,000 feet of thin-bedded to massive, medium-gray to dark-gray, tuffaceous siltstone and claystone with subordinate amounts of sandstone and shale locally

UNCONFORMITY

Tevu — Undifferentiated Eocene volcanic rocks
Several thousand feet of chloritized basalt flows and basalt breccias of submarine and subaerial origin

U D — Faults
Dashed where approximately located or indefinite, dotted where concealed
U, upthrown side; D, downthrown side

Contacts
Dashed where approximately located

45 — Approximate strike and dip of beds or flow

Active landslide

Scale in Miles

.5 0 1 2 3

Figure 3. View south from Neahkahnie Mountain. The community of Neahkahnie, at far left, is partly on a terrace segment, and the forested area is on stabilized sand dunes. A sandspit projects southward and deflects the Nehalem River to the south. (Oregon State Highway Div. photo)

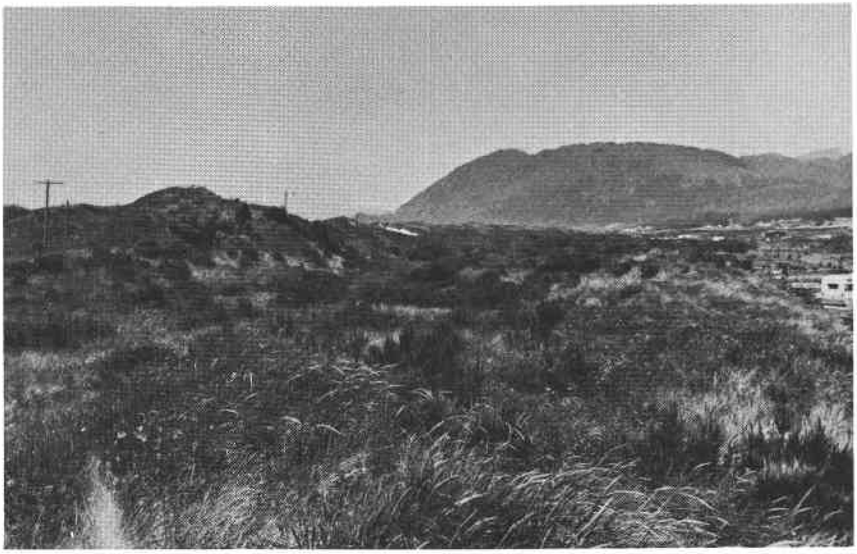


Figure 4. Foredune on the Nehalem sandspit. The dune is stabilized by marram grass, bushes, and young trees. Neahkahnie Mountain is in the distance.

longshore drifting of winter or the southward longshore drifting of summer.

Waves generated by wind move shoreward, where, on encountering the shallow water near the beach, they break and the water moves back and forth over the beach in the swash zone. Where waves strike the beach obliquely instead of head on, the water in the swash moves onto the beach obliquely and off again in the backwash. The repetition of this cycle imparts a zig-zag motion to the water particles as they are moved on and off the beach by successive waves. Sand particles moved by water in the swash zone follow a similar zig-zag path and are transported along the beach according to the direction at which the waves strike the shore. This movement of sand is referred to as beach drifting.

Just off the beach, water affected by the waves approaching the shore obliquely is caused to flow along the shore in what is termed a longshore current. Sand churned up by the turbulent water in the surf zone is moved by the longshore current in the same direction as sand is moved by beach drifting, and the combined movement is referred to as longshore drifting.

Where there is a marked change in the direction of the shore, as at the mouths of bays, some of the sand moved by longshore drifting is deposited in a sandspit, which is attached to land at one end and terminates in water at the other. The force of waves moves sand towards the bay, but the outflow of water from the bay presents an opposing force. The site of deposition of sand in the sandspit represents a position of compromise between these two forces. The southward-projecting spit in front of Nehalem Bay was built by the longshore drifting of sand in the summer months, when the winds along the coast come mainly from the north and northwest.

A foredune ridge extending along the Nehalem sandspit on its seaward side (Figure 4) is of recent origin and was formed by the accumulation of sand blown off the beach. The sand has accumulated in hillocks around logs and clumps of marram grass, a beach grass imported from Europe for the purpose of stabilizing dune areas along the west coast. As the hillocks increased in size, they coalesced to form a continuous, knobby ridge.

At its north end, the foredune merges into an older dune complex that is stabilized by a forest. Over most of their area the older dunes are superimposed on a segment of marine terrace. Along their edge closest to the mountain they rest on sedimentary bedrock, which forms the hilly land just south of the mountain. The town of Manzanita and part of Neahkahnie community are built in this area of older dunes.

Middle segment (map 2)

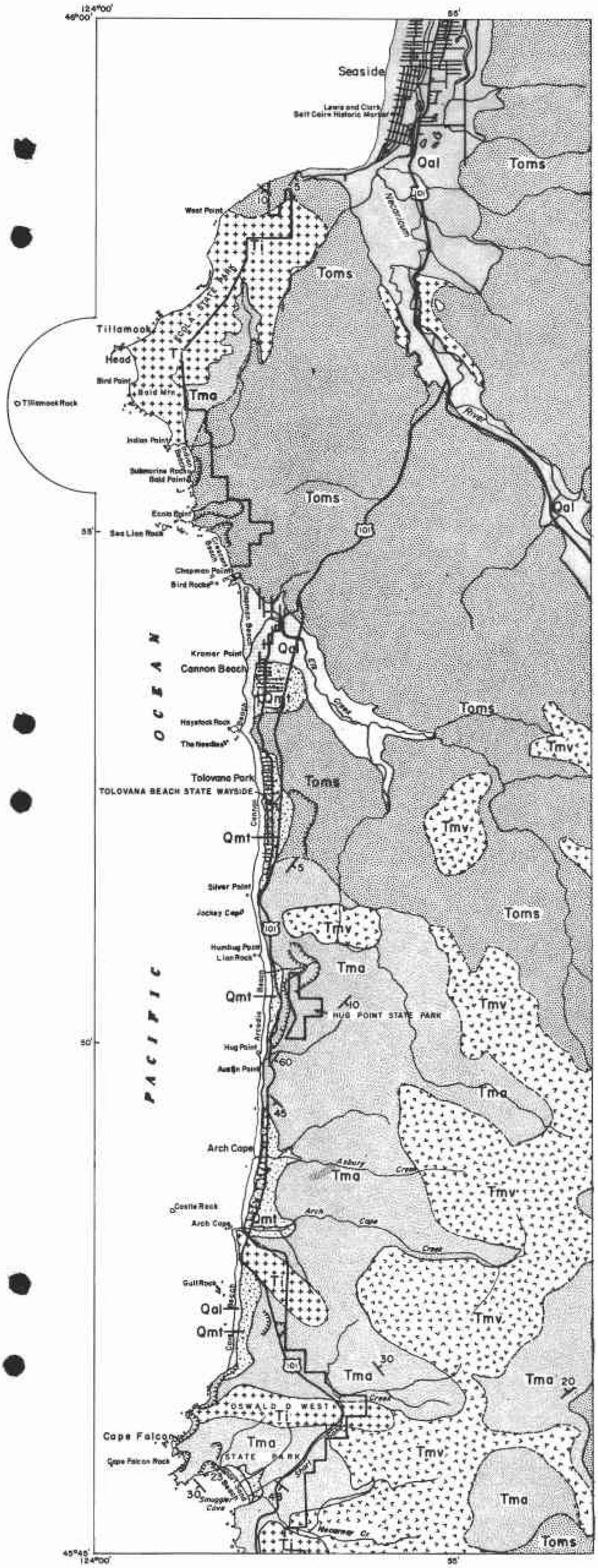
Basalt promontories with their associated shore forms and the beaches that lie between them characterize the shore between Neahkahnie Mountain and Tillamook Head.

Neahkahnie Mountain, which rises steeply from a hilly terrain of Astoria Formation north of Nehalem Bay, is made of coarse-textured basaltic rock that solidified at shallow depth in some form of igneous intrusion. The texture of the rock is distinctly coarser than that of basalt in other headlands, and the rock is properly referred to as gabbro. Somewhat elongate in an east-west direction, the mountain terminates in a high, steep sea cliff (Figure 5). The slope angle of the cliff is determined by joints that are steeply inclined seaward. As the base of the cliff is undermined by the waves, large slabs of rock break off along the joint surfaces and slide into the ocean. At the outermost point of the mountain, erosion has worked along joints in such a way that rock was removed from behind the cliff face to form a tunnel.

Figure 5. Cliff face on Neahkahnie Mountain. Cape Falcon is in the distance, and Smuggler Cove lies between these promontories. (Oregon State Highway Div. photo)

MAP 2

Neahkahnie Mountain to Tillamook Head



EXPLANATION

Qal — Alluvium and dune sand

Qmt — Marine terraces

UNCONFORMITY

Tmv — Miocene volcanic rocks
Localized accumulations of massive basalt breccia, basalt flows, palagonitic breccias and pillow basalts

Ti — Intrusive rocks
Middle to late Miocene basaltic intrusive rocks which include thick sills

Tma — Astoria Formation
Approximately 2,000 feet of consolidated to semi-consolidated, thick-bedded to thin-bedded, medium-grained, buff, micaceous, arkosic sandstone and interbedded siltstone of early Miocene age

UNCONFORMITY

Toms — Oligocene to Miocene sedimentary rocks
Over 5,000 feet of thin-bedded to massive, medium-gray to dark-gray, tuffaceous siltstone and claystone with subordinate amounts of sandstone and shale locally

Faults
Dashed where approximately located or indefinite, dotted where concealed
U, upthrown side; D, downthrown side

Contacts
Dashed where approximately located

45 — Approximate strike and dip of beds or flow

Active landslide

Scale in Miles
1 .5 0 1 2 3

Figure 6. Short Sand Beach and Smuggler Cove. The rock behind the beach and flanking Neahkahnie Mountain on the north is sedimentary.

Figure 7. Small cove between two points of land on Cape Falcon. The rock in the sea cliff is intrusive basalt overlain by sedimentary beds.

Lying between Neahkahnie Mountain and Cape Falcon to the north is Smuggler Cove with Short Sand Beach (Figure 6) at its head. The cove is in the Astoria Formation, which forms sea cliffs on both the north and south sides and behind Short Sand Beach. Several small streams flow into the cove. Where Short Sand Creek and Necarney Creek enter it at the south end of the beach, there is a small area of low terrace on which camping and picnic facilities have been built. The water in the cove is sufficiently deep to be used by small craft when the open ocean gets rough. The configuration of the cove gives protection against the strong northwest winds of summer.

Cape Falcon is a headland comprising two points separated by a very small cove. Like the other headlands along this part of the coast, Cape Falcon is composed principally of basalt, but the southernmost point, the one bordering Smuggler Cove, is mainly sedimentary rock. This appears to be an anomolous condition but is explained by the presence of basalt beneath the sedimentary rock. Basalt forms the northern point and is exposed beneath sedimentary rock in the sea cliff around the small cove between the two points (Figure 7). The basalt is a sill-like body which is inclined toward the south at such an angle that, although exposed in the cove, it is below the water's surface on the south side of the southern point. Here a very hard layer of sandstone, further hardened by the intrusion of the basalt beneath it, is at the water's edge and offers unusual resistance to erosion. The basalt, however, gives the main support to the point. Several shallow caves have been cut along fractures in the basalt on the south side of the small cove between the two points, and a tunnel, visible from the highway, passes through the tip of the point bordering Smuggler Cove.

Neahkahnie Mountain and Cape Falcon are parts of a headland complex that extends northward to Arch Cape and lies at the southern end of an extensive area of basalt that forms a mountainous terrain inland. Sedimentary rock is interspersed with basaltic rock, and coves with sand beaches at their heads are developed where belts of the sedimentary rock are sufficiently wide. Short Sand Beach and Cove Beach are examples of sandy coves cut into sedimentary rock in a dominantly igneous terrain.

From Arch Cape to the promontories of Tillamook Head, the bedrock is almost continuously sedimentary and the land is low. The lowland area is level where there is a terrace and irregular where ridges of the hills to the east project to the shore. Elk (Ecola) Creek has removed the terrace and formed an alluvial plain at the northern end of the lowland, and the business section of Cannon Beach is built on this plain. North of the city a prominent dune, Pompadour Ridge, lies between the beach and the alluvial plain.

The shore in front of the lowland is sand beach interrupted here and there by small points of land supported by basalt and in some places massive sandstone. One of the breaks in the continuity of the beach is at Hug Point, a cluster of small promontories and intervening short beaches (Figure 8). North of Silver Point, Cannon Beach extends without interruption as far as Chapman Point. The beach segment between Elk Creek and Chapman Point is sometimes referred to as Chapman Beach.

Besides the several small promontories of basalt along the shore, numerous basalt remnants in the form of rock knobs and sea stacks lie just off shore. The most notable of these is Haystack Rock (Figure 9). This stack is principally fragmental basalt cut by numerous dikes. Near its base and in the satellite stack attached to the south side there is sedimentary rock intermixed with the basalt, which suggests the rock is of submarine origin or of lava that poured into the sea. Haystack Rock can be reached at low tide by a strip of sand, a tombolo, that extends to it from the beach.

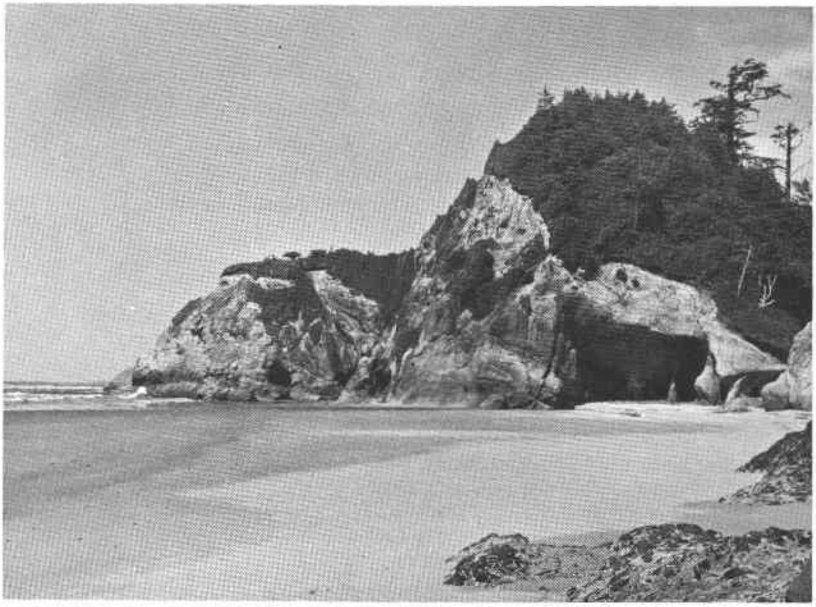


Figure 8. Beach and promontory at Hug Point State Park. The rock at this locality is mixed basalt and sediment and contains numerous sea caves, mostly in sedimentary rock. (Oregon State Highway Div. photo)

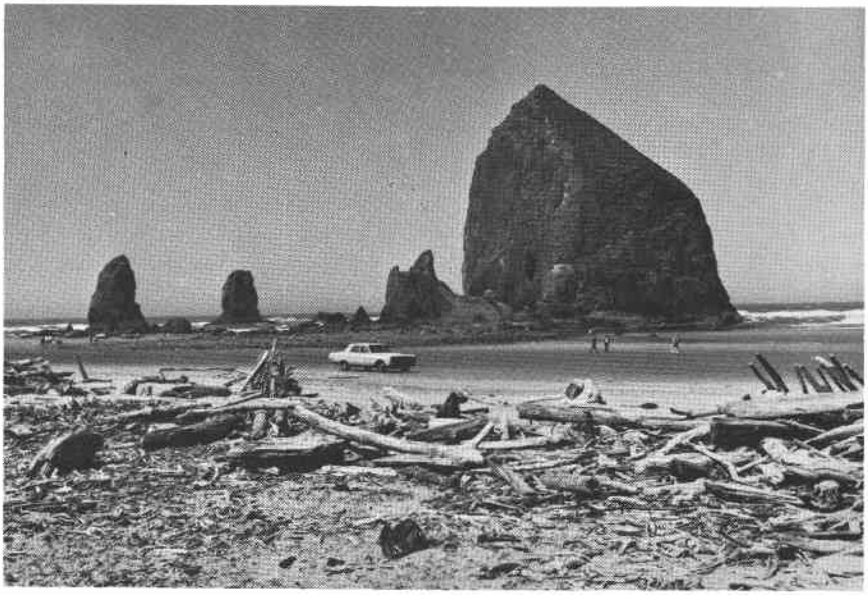


Figure 9. Haystack Rock is mainly of fragmented basalt. At its base and in the small "satellite" stack next to it, sedimentary rock is intermixed with the basalt.

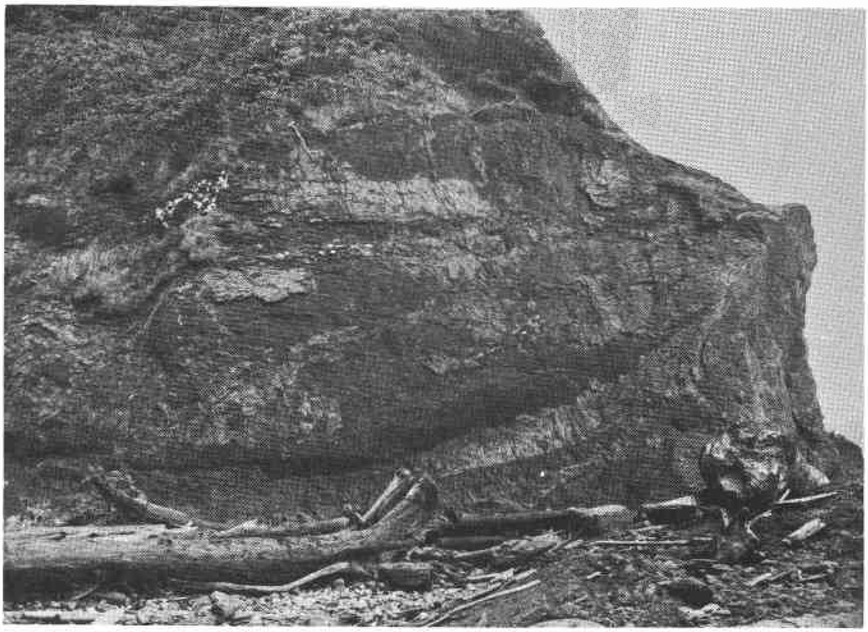


Figure 10. Interlayered basalt and sedimentary rock at Crescent Beach. The light bands are the sediment.

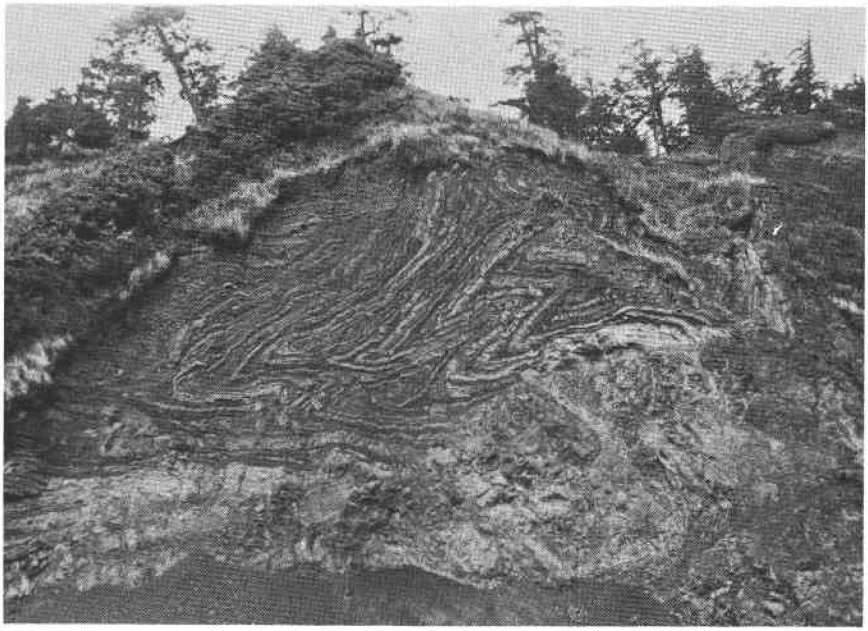


Figure 11. Contorted folding in sedimentary strata at the north end of Crescent Beach. This complex folding is probably the result of slumping in the sediment brought on by volcanic activity. A sill-like body of basalt lies at the base of the folded beds.

North of Cannon Beach is Tillamook Head, a complex of bold headlands, points of land, and intervening coves and shallow indentations. The main rock of this area is basalt, but in places basalt is complexly intermixed with sedimentary rock. Most of the basalt was emplaced as flows of both dense and fragmental varieties, and sedimentary beds are interlayered with basalt flows (Figure 10). Numerous basalt dikes and sills intruded the sedimentary strata.

The igneous activity, both intrusions and submarine flows, disturbed the sedimentary strata (Figure 11), which was not yet consolidated into firm rock, and unstable zones were formed in the rock masses. Where unstable zones are exposed to wave erosion, they are sites of landslides. Slides have been particularly active south of Tillamook Head between Chapman Point and Indian Point and are described by Schlicker, Corcoran, and Bowen (1961) and North and Byrne (1965). Rock in slide areas is predominantly sedimentary.

Destructive though they may be, landslides have had their role in shaping the indentations that lie between the points of land and have thereby made their contribution to the magnificent scenery at this locality. The coves that lie between Chapman and Ecola Points (Figure 12) and Ecola and Indian Points (Figure 13, 14) are both sites of ancient as well as active landslides. Bald Point, just south of Indian Beach, is the toe of an old landslide behind which is an active landslide area. The parking and picnic area at Ecola Point is on a landslide area that moved in February 1961 (Schlicker, and others 1961). Fortunately landslides in this locality move slowly, no more than a few feet a day, and take place during the winter months.

The rocks that lie off Chapman and Ecola Points mark former positions of these promontories, and the points once extended seaward much farther than the outermost rocks. As erosion continues the existing points will be destroyed, and their remnants will become units of the reefs as part of the very gradual but continuous change in scene along the shore.

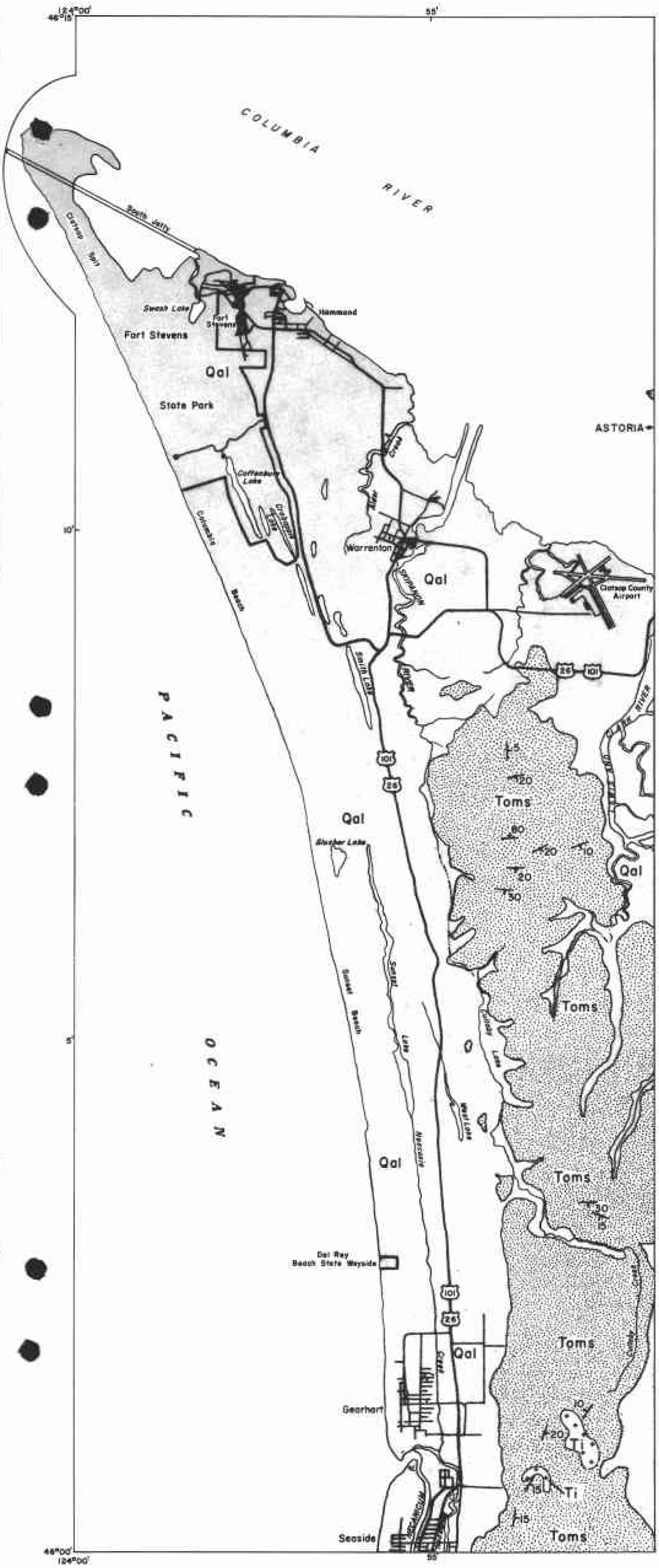
One of the most remarkable features of this part of the coast is Tillamook Rock (Figure 15), a 100-foot high basalt sea stack that lies a little more than a mile west of Tillamook Head. This stack, which was once part of the mainland, has survived the attack of the sea through the millenia that were required for the rock around it to be removed and the shore to be eroded landward to its present position. This stack is the site of Tillamook Lighthouse, which operated for more than 80 years until discontinued in 1962.

The main mass in the complex, Tillamook Head, consists of two major lobes separated by a broad, crescent-shaped indentation (Figure 16). The basalt along the front of the headland is dense and without layering and is some sort of intrusive body, probably a thick sill. Sedimentary rock underlies the lower slopes on the north side of the head. A high, steep cliff bounds Tillamook Head, and at numerous places, especially around the south side, indentations cut into bodies of sedimentary rocks impart an irregularity to the shore line. Narrow, rocky beaches that are not easily accessible lie at the base of the sea cliff.

Northern segment (map 3)

Stretching from Tillamook Head northward to the Columbia River is a strip of coastal lowland, the Clatsop Plains (Figure 16), which is covered mainly by dunes. At its southern end the strip is a little more than a mile wide, and in its northern part it is about 3 miles wide. The plain extends eastward along Young's Bay as river alluvium, and alluvial plains extend southward from it along Young's River and Lewis and Clark River.

MAP 3
Tillamook Head to Columbia River



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Scale in Miles

.5 0 1 2 3

Figure 12. Crescent Beach viewed from Ecola Point. Chapman Point, at its south end, appears to be a remnant of a basalt sill. Beyond are Cannon Beach and Haystack Rock. The mountains that form the skyline are of basalt. (Oregon State Highway Div. photo)

Figure 13. Indian Beach in the upper right of the photograph, is bounded on the north by Indian Point, composed of basalt, and on the south by Bald Point, the toe of a landslide. The sea caves at lower right are in basalt overlain by sedimentary rock. (Oregon State Highway Div. photo)

Figure 14. Indian Beach and Bald and Ecola Points. Sea Lion Rock, near the end of the reef off Ecola Point, is an arch. The rock in the reef is principally basalt, but some complexly folded sedimentary rock is intermixed with it. (Oregon State Highway Div. photo)

Figure 15. Tillamook Rock is a basalt sea stack lying about a mile west of Tillamook Head. Use of the lighthouse was discontinued in 1962 after 80 years of service. (Oregon State Highway Div. photo)

Figure 16. Tillamook Head, a basalt headland, is the central feature of this aerial photograph. The Clatsop Plains extend northward to the Columbia River in the distance. Indian Point is at center of photograph, and Ecola Point is at right of center. (Univ. Calif. Hydraulic Eng. Lab. photo)

The dunes of the Clatsop Plains are described and their origin is well explained in a book on the dunes of the Oregon and Washington coast by Cooper (1958), and the writer of this article draws heavily from Cooper's work. A map that shows the distribution of Tertiary bedrock, dunes, and alluvium accompanies an article on the hydrology of the Clatsop Plains by Frank (1970).

Dunes of the Clatsop Plains are impressive in the extent and uniformity of individual dune ridges and their parallel arrangement with each other and with the shoreline (Figure 17, 18). Ridges that vary only slightly in height and width and that curve gently to conform to the shoreline can be traced for long distances, in places for miles.

The Clatsop Plains is an area of fill where sand has been deposited parallel to a westward shifting shoreline along a coastal indentation which extends from Tillamook Head in Oregon to Cape Disappointment in Washington. Filling (prograding) began some time after sea level reached its maximum height following the most recent glaciation, and the origin of the dunes is closely tied to the prograding of the shore.

Prior to prograding, the shore was along the Tertiary upland, and the mouth of the Columbia River lay between Cape Disappointment on the north and the upland east of the Skipanon River on the south. Cooper (1958) believes that building of the plains was initiated by the deposition of a northward-projecting sandspit at the south side of the mouth of the Columbia River and that progradation along the shore began with construction of a sand bar in front of what is now Cullaby Lake. This was followed by the building of a succession of sand ridges along the shore as the beach shifted westward. Most of the ridges originated as foredunes. Sand transported mainly

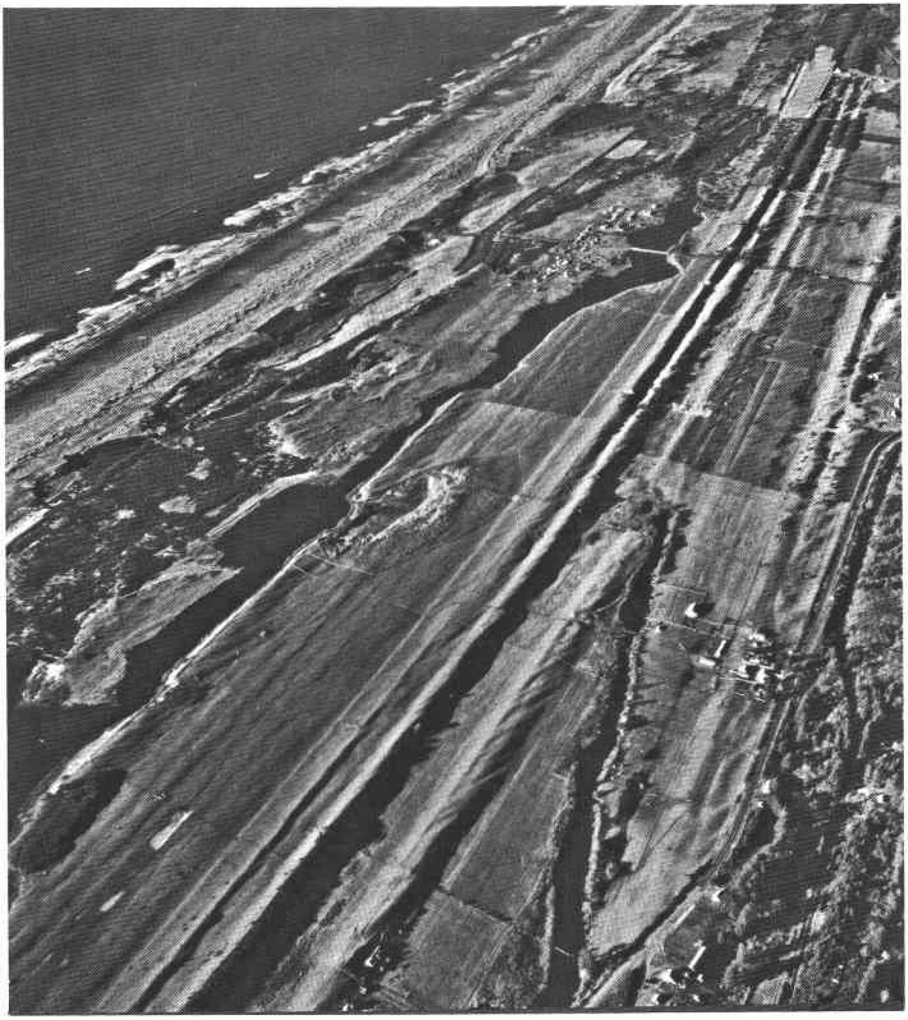

Figure 17. Dune ridges and lakes on the Clatsop Plains. Sunset Lake is the long one extending from the lower left corner of the photograph. Though it doesn't conform strictly to a single interdune valley, its shape is determined by the ridge-valley pattern. The north end of West Lake, right of center in the lower part of the photograph, cuts diagonally across the ridge-valley pattern and probably was a channel that connected to the sea when the shore stood along the edge of the dune ridge immediately west of it. (Univ. of Calif. Hydraulic Eng. Lab. photo)

Figure 18. Green and fairway (hole 14) in an interdune valley on the Astoria Country Club golf course.

Figure 19. Coffenbury Lake in Ft. Stevens State Park is one of the largest interdune lakes on the Clatsop Plains. (Oregon State Highway Div. photo)

by the south-flowing summer currents washed up onto the beach, where it was picked up by wind and redeposited just behind the beach. Cooper believes that where a ridge has a wide strip of bog or a lake of considerable size behind it, origin as an offshore bar is indicated. Once a bar becomes exposed above sea level, it comes under the influence of the wind, and its size is increased by the addition of wind-blown sand.

Point Adams was the terminus of the sandspit that initiated progradation and was the end of land until the beginning of jetty construction in 1885. With the building of the south jetty, sand filled in over the shoal area off Point Adams to form Clatsop Spit. A wedge-shaped area of new land that is about half a mile wide at Fort Stevens was built up along the shore south of the spit. Sand was added to the beach as far south as Seaside, and parts of the beach that were formerly rocky are now covered with sand. A foredune ridge stabilized by marram grass lies behind the beach at Clátsop Spit and continues along the shore to the south, where it widens out into a terrain of grassy hillocks. South of Sunset Beach the hillocks give way to a narrow, grassy plain that lies between the beach and the first dune and extends to the mouth of the Necanicum River.

The numerous lakes on the Clatsop Plains owe their origin to the dunes. Most occupy depressions in the interdune valleys and are generally elongate in the direction of the ridges. Sunset (Figure 17), Coffenbury (Figure 19), and Smith Lakes are examples of this type. Cullaby Lake was impounded against the upland by dune sand, and the configuration of its eastern edge conforms to the erosional surface on the upland. Valleys in the topography became the finger projections of the lake and the dividing ridges the points of land between the fingers.

Many of the lakes have no surface outlets or appreciable inlets. The level of the lakes conforms to the level of the ground water table, and movement of water into and out of the lakes is by percolation through the sand. Sunset Lake has an outlet in Neacoxie Creek, which, although it is located within half a mile of the ocean at the point it leaves the lake, must flow southward about 4 miles to join Neawana Creek and the Necanicum River before it enters the ocean. The Necanicum River, which is deflected northward nearly 3 miles by a rock and sand barrier, is the only stream that crosses the beach between Tillamook Head and the Columbia River. North of it the wide, gently sloping beach extends without interruption for more than 15 miles.

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Glossary

Alluvium: Sediment deposited by streams.

Basalt: Dark-colored, fine-grained rock of volcanic origin.

Bedrock: Solid rock beneath soil or sediment layer. May be exposed.

Dike: Tabular-shaped intrusive igneous body that cuts through another rock.

Estuary: Lower part of river affected by tides and mingling of salt water from the ocean with fresh water of the river.

Foredune: Dune ridge that forms just behind and parallel to the beach.

Formation: 1. Land form. 2. Body of rock, the parts of which are related in space, time, and/or origin, such as Astoria Formation.

Igneous: Refers to rock formed from molten matter (magma) that originates deep below the earth's surface.

Intrusion: An igneous rock body that solidifies below the surface of the earth where magma invades older rock.

Joint: In geologic language, a fracture or parting which interrupts the physical continuity of a rock mass.

Quaternary: The latest Period of geologic time; began about 2 million years ago. Includes Pleistocene (Ice Age) and Holocene (recent) Epochs.

Sea stack: Small prominent island of bedrock near shore.

Shale: Laminated sedimentary rock made of solidified mud.

Shear zone: A zone in a rock body where the rock has been broken into fragments by fracturing and shearing.

Sill: A tabular-shaped intrusive igneous body that has been emplaced parallel to the bedding of the intruded rock.

Terrace: Bench-like landform cut into bedrock or built up by sedimentary deposition. Oregon shore terraces have aspects of both.

Tertiary: Period of geologic time between 65 million and 2 million years ago. Includes Paleocene, Eocene, Oligocene, Miocene, and Pliocene Epochs in order of decreasing age.

* * * * *

NEWPORT AREA MAPS ON OPEN FILE

The U.S. Geological Survey has released on open file three preliminary bedrock geologic maps of six quadrangles in the area of Newport, Oregon, by P. D. Snavely, Jr., N. S. MacLeod, and H. C. Wagner. The maps are printed in black and white on three sheets as follows: Cape Foulweather and Euchre Mountain, Yaquina and Toledo, and Waldport and Tidewater quadrangles. They are available for inspection at the Oregon Department of Geology and Mineral Industries in Portland, and copies can be purchased at $1.00 per sheet at a scale of 1:62,500, or $1.50 per sheet at a scale of 1:48,000. If ordered by mail, add 10 cents per sheet for cost of mailing.

* * * * *

COLEBROOKE SCHIST DESCRIBED IN SURVEY BULLETIN

"The Colebrooke Schist of Southwestern Oregon and its Relation to the Tectonic Evolution of the Region," by R. G. Coleman, has been published as Bulletin 1339 by U.S. Geological Survey. The 61-page bulletin with one plate in pocket is for sale by the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. The price is $1.00.

The Colebrook Schist occurs in the Klamath Mountains in western Curry and Coos Counties. It consists of sediments and lavas similar to the Galice Formation which were metamorphosed in Early Cretaceous time and in Late Cretaceous were thrust on top of shelf and trench sediments that range in age from Late Jurassic to Early Cretaceous.

* * * * *

ASSESSMENT WORK NECESSARY TO RETAIN MINING CLAIMS

A change in Federal government regulations which became effective September 9 says that persons claiming minerals under the Mining Claim Act of 1872 must do the $100 annual assessment work or face loss of their claim. The change was announced by Archie D. Craft, State Director of Bureau of Land Management, the agency which administers the mining laws in Oregon.

The new regulations say that failure of a claimant to do the annual work in either labor or improvements will render the claim subject to cancellation. Failure will also subject the claim to relocation by another party unless the original locator or his successors in interest resume the annual work before someone else "jumps the claim."

Craft said, "We anticipate the new rules will help appreciably in clearing titles to public lands which are clouded by abandoned or dormant mining claims."

* * * * *

SOME COMMERCIAL AND INDUSTRIAL USES OF SAND AND GRAVEL

Many people, if asked about minerals mined in Oregon, would not think of sand and gravel. Yet the mining of sand and gravel constitutes over a third the mineral production in Oregon -- $26 million in 1970. Some of its many uses:

Concrete aggregate	Road and highway construction
Bitulithic aggregate	Landscaping (sand, cobbles, boulders)
Railroad ballast	Pebble mills (grinding media)
Riprap and jetty stone	Cobblestones and flagstones
Filter sand	Highway sand (icy pavements)
Sandblasting	Artificial beaches
Exposed aggregate	Grinding and polishing
Fill material	Roofing sand and gravel
Engine sand	Percolation tower fill (chemical process industry)
Sand traps (golf)	Percolation tank fill (sewage treatment)
Cigarette urns	Aggregate for French drains
Poultry grit	Aggregate for plunge-pool energy absorption
Floor sweep	Sand for vehicular emergency speed reduction traps
Leachate field fill	Sand for egg timers
Sand drains	Make-weight and ballast for hollow objets d'art
Moulding sand	Ballast for "squaw" fence posts
Mortar sand	Wire saw sand
Stucco sand	Plaster sand

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